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PHYSIOLOGY OF MUSCLE ACTION AND FATIGUE APPLIED TO MYOLOGIC TECHNIQUES*

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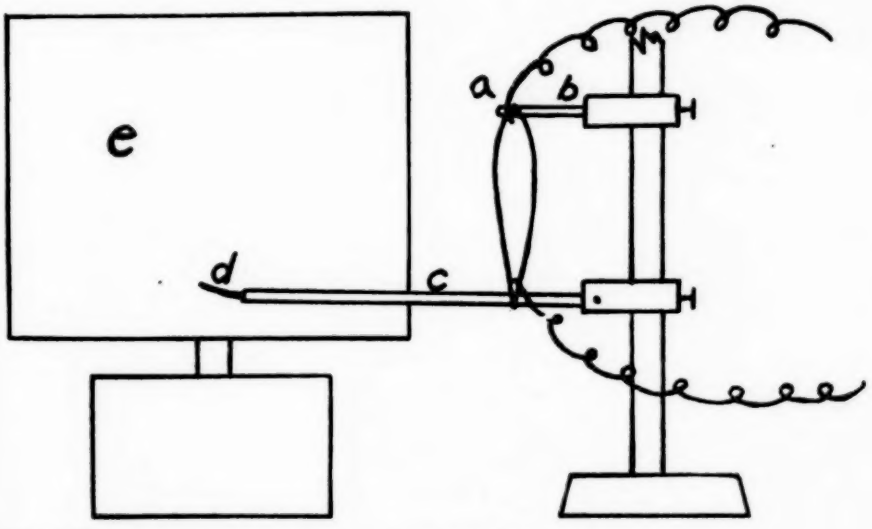
Today Optometry has advanced farther and farther into the realm of Myologic work. New techniques are constantly being developed. Under all lies the basic foundation of muscle action and neuro-muscular fatigue, a subject which we should have well in hand if we are to cope intelligently with present day muscular anomalies, the phorias and tropias. An attempt has been made here to gather facts and correlate them so that the material may be directly applied to our muscle work. A broad insight into the principles of physiology of muscle action will aid us materially in this field.

Figure 1



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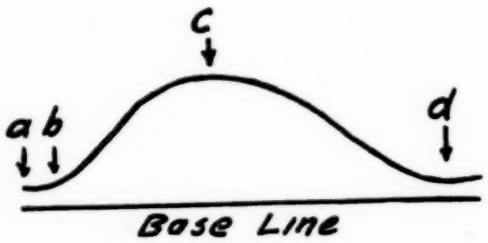
Experimental Method. In our experiments on muscle contraction, relaxation and fatigue, we have used a set-up which is explained in Figure 1. We used the Gastrocnemius muscle of the hind leg of a frog. The upper tendon (a) is attached to a rigid support (b). The other end is fastened to a movable arm (c) acting as a fulcrum with a stylus (d) at the free end. This scratches a line upon a smoked paper on a revolving drum of a kymograph (e) whose speed of revolution is known. The recorded graph will give us an accurate picture of the muscle action and also the elapsed time. Stimuli are given with the electric current.

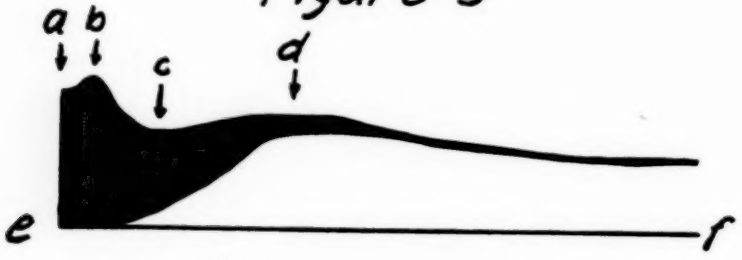
Figure 2



ab-Latent Period.
bc-Contraction.
cd-Relaxation.

Simple Muscular Contraction. When we send an electric impulse through the muscle, the result is a rapid shortening, followed by a rapid lengthening. The graphical picture is a curve. (Figure 2.) Close analysis of this curve shows: (1) a latent period, in which changes are taking place within the muscle fibers, (2) a period of contraction, and (3) a period of relaxation in which the muscle passes back into the resting state.

Figure 3



ab-"Staircase Effect"
bc-Fatigue
cd-Contracture

Repeated Stimulation. The muscle in this case was stimulated five times a second. Figure 3 shows the resulting picture. The kymograph drum was revolving very slowly so that the overlapping lines produced a solid figure. The muscle soon was unable to relax to the base line "e f" but remained in a state of "partial contraction" as it received the next stimulus. The rapid rise at first is the "staircase effect" of the first few contractions, each one greater than the one preceding. Then there is a sharp drop as fatigue sets in. The muscle then passed into a tetanized state as shown by the last two-thirds of the line.

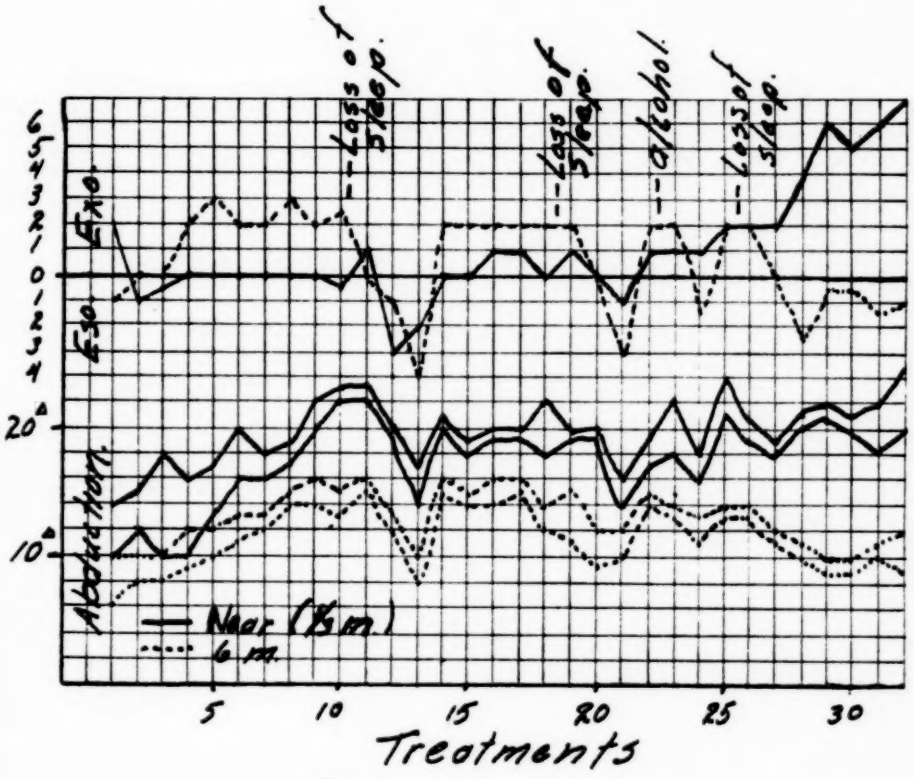


Figure 4.

Increasing Stimulation Strength. If we begin with stimuli at regular intervals, at first very weak and gradually increasing in intensity, we will see that:

1. At first there is no action. The stimulus has not yet reached the "threshold."
2. Action now starts feebly. The threshold is crossed.
3. Action increases with increase in stimulation strength.

4. Action does not increase any more. We have reached the *maximal contraction* or the greatest contraction of which the muscle is capable, no matter how strong the stimulus.

The explanation of this action is known as the "all or nothing principle." At first only a few of the total number of fibers were contracting. These were acting to the fullest extent. On increasing the stimulus more and more fibers joined them until all the fibers were contracting. At this point the maximal contraction was reached.

Contraction. (Production of Lactic Acid and Immediate Energy) All muscles in contraction produce lactic acid. The belief is that the acid is formed during the contraction itself and that the formation of the acid is the means whereby the energy is released. The substance from which it is formed is now believed to be glucose or a derivative.

When a muscle contracts, the immediate energy is:

1. Surface Energy—developed in such a way as to cause muscle fibers to develop tension.
2. Energy is Depleted—by deveolping tension.
3. Oxidation—restores energy.

Relaxation. If muscular contraction is due to the formation of lactic acid, then relaxation must be due to the removal of this acid. In fresh muscles relaxation is almost as rapid as contraction. In a muscle that has been stimulated many times, the relaxation may be many times slower. Why? The lactic acid combines with sodium compounds to form *sodium lactate* which is a neutral salt. Thus the acid is removed and the muscle may relax. After repeated stimulation the amounts of sodium lactate have increased and accumulated in the muscle fibers. One of the laws in chemistry states that the products of a chemical reaction must be removed if the reaction is to continue. Muscle relaxation thus becomes much slower until the lactates have been removed. It may be accomplished in three ways.

1. It may diffuse into the blood and be eliminated by the kidneys.
2. It may be oxidised, giving rise to sodium bicarbonate, carbon dioxid and water.
3. The molecules may be changed back into lactic acid again and thus made available.

The first of these methods is very injurious, as the accumulation of lactates in the blood is responsible for body fatigue. Slight exercise would be excessively fatiguing if this were the case. The second process would liberate too much heat. In reality, a small amount of fuel is oxidised. The available energy thus liberated is used to convert the lactates back into lactic acid. The fuel that is oxidised is sodium lactate, fat and glucose.

Summary of Contraction and Relaxation

1. Stimulus.

2. Latent period. Formation of lactic acid.
3. Tension developed. Contraction.
4. Lactic acid formed.
5. Lactic acid reacts with sodium bicarbonate to form sodium lactate.
6. Relaxation.
7. Recovery oxidation.

Muscular Work. When a muscle has no load it does no work. We will gradually add increasing loads and notice what happens to the amount of work done. More and more work is done with increasing loads—up to a limit. After that, with more load, less work is done, and finally the muscle will not respond at all to the stimulus.

Muscle Fatigue. We shall stimulate a muscle a number of times and see what results. (Figure 3) At first there is a marked increase in the contractions. Following this is a slowing up in the relaxations. The muscle still contracts with the same force, but the relaxation is slowed up by the fatigue products. It has not recovered from one stimulus before it receives another. Thus the muscle remains in a state of *"partial contracture."* This, again, is due to the accumulation of lactic acid in the fibers.

Neuro-Muscular Fatigue. The body has a method whereby any muscles can not become exhausted. A fatigue of the nervous system occurs, acting as a nerve block to prevent the passage of any more impulses to those muscles. Fatigue occurs in two places in the nervous system:

1. In the synapses. Wastes increase the resistance at this point.
2. At the junction of skeletal muscle fibers and motor nerves. (Motor end-plates.)

Synaptic and end-plate fatigue are followed very rapidly by recovery. Total restoration, of course, takes much longer. Adrenaline, secreted by the medulla of the adrenal glands (one of the endocrines) has the properties to counteract this type of fatigue by eliminating the resistance at those points. This occurs only at times of emotional stresses, however.

General Body Fatigue. The exhaustion following excessive exercise, over work, loss of sleep, etc., is due to the presence of lactates in the blood stream. It is a peculiar fact that fatigue does not always imply a state of muscular inefficiency, but a reduction in efficiency of certain nervous structures. This was shown in the preceding section. Not until the lactates have been removed from the blood can the muscles regain their normal power. The nerve fibers are practically indefatigable. The passage of an impulse over a nerve fiber fatigues it for only a fraction of a second. Then it is as good as ever. The fatigue occurs at the synapses, and is not present in the axons or dendrons. It is an interesting fact from an efficiency standpoint that our muscles have a rating of only twenty

per cent. The other eighty per cent is expended as heat. This accounts for overheating after physical exercise.

Beneficial Effect of Exercise. The response to a stimulus after a period of inactivity is weaker than it would have been if the muscle had been exercised for a while previously. Athletes all go through this process of "warming up" to get their muscles in a state of maximum efficiency for their event.

Practical Applications. It is very evident that a myologic procedure which conforms to these physiologic principles will give us the most gratifying results. Let us correlate a few of these facts with present techniques.

In exercises in which Risley rotary prisms are used, we are giving repeated stimulation. Here we must be careful that the stimuli are not too close together. They must be slow and with a short rest period of a few seconds between them for relaxation. There are two types of exercise. We may actually produce diplopia and then bring about a return to fusion. We may also rotate the prisms to a point just within the breaking point and not cause diplopia. I believe a rest of a few seconds between stimuli an essential feature.

Any instrument for muscle building must give a stimulus which is between the "threshold" and the maximum stimulus to which those muscles are capable of contracting. Half way between these two points should give a strong stimulus, cause good contraction, but not producing excessive fatigue. Physiologically, we want most of the individual muscle fibers contracting to our stimulus.

Turning rotary prisms base out, then, essentially puts a weight on the medial recti, sends an increased nerve flow to those muscles, and inhibiting the flow to the lateral recti. Here, again, we are interested in the amount of "work done" and the work that those muscles are capable of doing. The breaking point in diopters is the measure of work done.

Relaxation periods are extremely necessary, both short ones at short intervals and longer ones at greater intervals. This period allows full relaxation of muscles which we have kept contracting. It also allows part of the lactates to be removed and blood changed, preventing fatigue.

Any myologic treatments should be brought to an end before fatigue has begun to develop to an appreciable extent. A new case will tire much more quickly than a case that has been exercised several times.

General body fatigue will have a tendency to retard progress of myologic work because of synaptic and end-plate insulation. Best results, therefore, cannot be obtained if the patient is in such a state. Common colds, loss of sleep, excessive use of drugs and alcohol, and other excesses will all retard muscle building.

Example. (Case record of J. B. H., age 23 years.) This case has been having daily treatments for the reduction of Myopia. His record of daily observation accurately shows the relationship of ocular muscle

tone and balance to general body tone. Relapses in muscle balance go hand in hand with general body fatigue, due, no doubt, to the presence of lactates in the blood in those tissues. The graph in Figure 4 shows this relationship very clearly.

Along this line, I might add that his refraction was originally —2.50 O.U. A half diopter was removed after the twelfth treatment. Another half diopter was removed after the twenty-sixth treatment. The refraction is now —1.50 O.U. Visual acuity is still 20/16 O.U. and his uncorrected vision has improved from 15/200 to 20/100.

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DYNAMIC RETINOSCOPY*

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One of the greatest contributions to the science and art of refraction made by optometrists has been in the development of dynamic retinoscopy. Static retinoscopy was discovered and developed by our medical colleagues and was taken up by optometrists many years later. The tables seem to be turned in the case of dynamic retinoscopy. This method was discovered and has been elaborated by optometrists from A. Jay Cross down and is just now making some headway amongst the medical refractionists.[1]

The trials and tribulations of dynamic retinoscopy during and since Cross' day have been many and varied. Hailed by Arrington with the statement that dynamic retinoscopy professionalized optometry, it was attacked by others with equal vigor because of its apparent unsoundness. And dynamic retinoscopy, strictly speaking, in its early presentation did appear scientifically unsound. The writer was among the early severe critics of the theory and an article some fifteen years ago provoked a general discussion of the method in which the best international minds in optometry took part. Notable contributions were made at the time by Lionel Laurence, who even expressed the fear that dynamic retinoscopy may threaten the very existence of optometry.

Cross with all his vast experience, knowledge and clear mind could not effectively clear away the apparent fallacies of the method. Big-minded as he was, he accepted sound criticism gracefully and merely said that the theory is sound and the practice is workable despite apparent fallacies. He claimed that it was up to the younger men to search and search until they found the cause of the confusion. He felt that this confusion would be ultimately cleared up and that dynamic retinoscopy would develop beyond his original work.

It has been a frequent occurrence within the past several years to see articles on dynamic retinoscopy in which the original theories of Cross have been entirely discarded. New theories have been presented, sometimes on the basis of clinical experience, sometimes on the basis of

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(1) The origins of dynamic retinoscopy, however, go back to a period before Cross, to the nineties of the past century in the work of Drs. Greef, Axenfeld, Herr and Heine.

theoretical deductions and sometimes on mere suppositions. The relative merits of some of these theories may be gleaned from the fact that one writer in criticizing the theory of another says the latter's reasoning is about as sound as the logic involved in the statement that because 6 and 4 make 10, 6 minus 4 also make 10.

The writer heeded Cross' advice to search for the cause of the apparent fallacies and establish the soundness of dynamic retinoscopy. That he was successful in this work may be judged from the following citations from Atkinson & Woll's recent book on Dynamic Skiametry. On page 66 the authors write: "To Dr. Joseph Pascal of New York must be given the credit for perceiving and pointing out this dual method and significance of the test." On page 67 the authors write: "It would seem, therefore, that the whole confusion which has attended the performance and interpretation of dynamic skiametry since Cross' day must be laid to the confusion between purpose and method, which it remained for Pascal to clear up."

Many have criticized Cross' theory and technique because they claimed that Cross by his method of ciliary relaxation measured primarily negative relative accommodation. In other words the additional plus lens found represented not latent hyperopia, ciliary spasm, *inefficient* accommodation, *insufficient* accommodation, etc., but primarily negative relative accommodation. Laurance, Sheard, Atkinson & Woll have especially stressed this point in one way or another. But while it is true that in some cases Cross' findings may have included some relaxation due to the negative relative range the fundamental soundness of his premises are not shaken thereby. Cross himself realized the play of other factors in the test and distinctly warns against prescribing from the findings of any one test. There is a gap between "findings" and "fittings," he said, and several methods should be used from the *findings* of which should come the ultimate *fitting*.

In dynamic retinoscopy one must keep in mind the fundamental difference between *forcing* accommodative relaxation and permitting *free* accommodative relaxation. It is this latter kind of relaxation that Cross had in mind. Negative relative accommodation represents primarily the extent of accommodative relaxation with a fixed convergence when the accommodation is forced to relax in the interests of maintaining single binocular vision. Cross' method of working, at least the purpose behind the method, was *not to force* accommodative relaxation, but merely to allow accommodative relaxation when there is a tendency for such relaxation to take place. It is inappreciation of this fundamental difference that has caused so much confusion and given rise to apparent fallacies in Cross' method, as so aptly expressed in the previous quotations from Atkinson & Woll's book.

The matter of the "locking point" of Cross has also been a target of criticism. Now the term is brief and expressive though perhaps unfortunate as it suggests to many a sort of rigidity, a veritable lock. But Cross

certainly did not mean it in this rigid sense. That there is a sort of locking point cannot be questioned if one goes a bit into the physiology of it. The accommodation and convergence are certainly interrelated functions irrespective of which is captain and which is mate. When two activities are thus interrelated there is certainly in their associated work a certain amount of activity of one, no more, no less, that best fits a corresponding amount of activity in the other. When these two activities thus exert their "best" amounts of work, we can say they are in physiological balance. It is this stage of physiological balance that Cross termed the "locking point." When the accommodation and convergence are in this state of balance they work comfortably. Otherwise they work uncomfortably. The very discomfort experienced is an expression of this urge for equilibrium. This conception is in line with the modern theory of complacency in psychology.

It is true that the accommodation and convergence can be dislodged from this state of balance, but when so dislodged there is always a tendency for them to get back to this stage of balance. Furthermore once they reach this balanced state they will not *easily* let go. They can be *forced* to let go, but they have a tendency to stick. In this sense this state of balance may be regarded as a "locking point."

The writer realizes the contributions made to dynamic retinoscopy by such men as Southall, Treleaven, Sheard, Atkinson & Woll, Petry, Bestor, Tait, McFadden and others. Dynamic retinoscopy could not stand still; it had to develop and in the course of its development modifications of technique and a variety of new applications were introduced. But this development in so far as it is itself sound is perfectly compatible with the fundamental soundness of Cross' basic premises.

Were Cross' theories really unsound it would have been futile to try and bolster them up from a feeling of hero-worship. And unquestionably all those who knew this grand old man in optometry loved him and cherished some of that hero-worship feeling. But fortunately Cross' basic premise when rightly understood is absolutely sound in theory and workable in practice. The edifice of dynamic retinoscopy whatever later modifications, extensions, elaborations and ornamentation may be added on, rests primarily on the soundness of Cross' original premises.

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THE SCIENCE OF VISION. AN HISTORICAL THESIS ON THE PROGRESS OF ITS DEVELOPMENT*

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FOREWORD

For a better understanding and comprehension of the achievements of mankind in any particular field of human endeavor, it is well to keep in mind a general outline of the PROGRESS of CIVILIZATION.

For while the HUMAN FAMILY as a whole has made marvelous progress during the forty centuries of recorded history, yet it has, like the individual, had its spells of sickness and depression, and even its periods of retrogression, which have materially checked the current of moral and intellectual improvement, and delayed for centuries the sum total of achievement in many fields of SCIENCE.

Such an historical outline of the DEVELOPMENT of CIVILIZATION may be divided into six periods:

1. Religious Philosophy—2000 B. C. to 400 B. C.
2. Moral and Political Philosophy, Empirical Science, Art, and Literature—400 B. C. to 200 A. D.
3. Decline of Philosophy, Science and Art—200 A. D. to 400 A. D.
4. The Dark Ages (or Religious Dominance)—400 A. D. to 1400 A. D.
5. The Renaissance (the Revival of Philosophy, Science, and Art)—1400 A. D. to 1600 A. D.
6. Physical Sciences, Mechanics and Invention (especially)—1600 A. D. to present.

It is well to bear in mind also, that no SCIENCE, and especially no EMPIRICAL SCIENCE, has been created by any one man, nor carried to perfection in any one country, nor in any particular epoch. All MEN of SCIENCE are indebted to those who have preceded them. Each has builded upon the observation and surmises of his predecessors. The foundation stones of SCIENCE have been laid by very few. Many more have added to the superstructure, and many have had their proffered ideas rejected.

*Submitted for publication June 13, 1931.

The narrative to which your attention is invited is an attempt to set forth in sequence the development of that particular SCIENCE which embraces our knowledge of the HUMAN EYE and of VISION. We wish to show that the Science of OPTICS was begotten by the Astronomer, born of the Anatomist, and nurtured by the combined labors of the Mathematician, the Physicist, the Physiologist, and the Psychologist.

The brevity of the thesis has necessitated the omission of the names and achievements of many men of the past century, and a few now living, whose investigations and deductions have added materially to our present knowledge.

If the story has been told in a manner to hold the attention of that reader who is particularly interested in the subject of VISION, the writer shall feel amply repaid.

H. L. F.

THE SCIENCE OF VISION

How do we see? Probably one of the first questions that ever aroused the curiosity of man; and one of the last to be answered.

The contemplation of the question takes us back to the beginning of recorded history.

Long before cities were built, and temples were erected, and marble was sculptured, and coins were stamped, and musical instruments were invented, we see the Chaldean Shephards, on the Plains of Ur, watching their flocks by day, and the stars by night.

They were no less awed by these "Wandering fires," of the firmament, than by the "divine fire" in their eyes, which enabled them in some mysterious way to see the glories of the Heavens.

Neither Abraham, the most august character of Biblical history, who saw, with an exalted faith, his religious concept of the One True God supplant the idolatrous teachings of the ancient world;— nor Moses who from Mount Sinai saw the Ten Commandments traced on the tablets of stone by the "finger of God;"—nor Solomon, who in all his fabled splendor, preferred wisdom to all earthly riches;—nor the Prophets of Israel who saw, with a prophetic faith, the coming of the Messiah;—nor the Three Wise Men of the East who followed the beacon star to the sacred manger in Bethlehem; none of these religious teachers—and they were the learned men of their tribes—had any conception of how God had made them to see the glories of his handiwork.

We may find some excuse for this in the fact that the great thinkers of those sixteen centuries from Abraham to Socrates were concerned rather in the "things of the spirit" than in the "things of the flesh." They were occupied in the contemplation of their relations and duties to God and their fellow-man. It was an age of theosophy and of spiritual orientation.

But as the centuries passed, and great cities developed, and marts of trade, and commerce, and art, and science, and what we are pleased to

call "civilization," the age of religious faith and fervor seems to wane, and to be overshadowed about the fifth century B. C. by an era of moral and political philosophy; when the human mind inclined to the study of ethics and moral philosophy, and politics, and military training, and astronomy, and geometry, and architecture, and sculpture, and painting, and literature, and oratory, and finally, in the last days of Rome, to material riches, and sensual gratification.

During this period of six or seven centuries, and especially in Greece, science and art in nearly every field of endeavor was carried to the highest point of human attainment.

Among the Philosophers we find Socrates, the first great martyr to the "freedom of speech";—and Plato, his most learned disciple, whose arguments on political philosophy have been translated into all languages and will ever be an inspiration to the politician and the statesman;—and Aristotle, who was universally regarded the most learned man of his age, and who still is thought of as one of the master minds of all time.

Like Plato he established a select school in Athens, where he might teach what, and whom, he chose. And the reputation of these schools, the Academy of Plato, and the Lyceum of Aristotle, made Athens the world centre of education and culture for many centuries.

And yet all the knowledge of these schools concerning the human eye, may be summed up in the statement by Aristotle, that vision is no doubt due to a "divine essence" in the eye.

The fame of Aristotle having spread to distant lands, the priests of Babylon and of Egypt sent to him the records of the "Heavenly Bodies," which they had been making for more than a thousand years, and these, together with his own investigations and deductions, laid the foundations of Astronomy.

The writings of Aristotle attracted many into this field of investigation, and for four centuries, in Greece, and Egypt, and Asia Minor, the study of the stars became the intellectual pastime of the learned.

Among them we find many eminent names:—men who through centuries of recorded observations, and a deductive reasoning that has never been surpassed, raised Astronomy to the dignity of a science:—such men as Thales, who first taught the rotundity of the earth, and sun, and moon:—and Aristarchus, who measured the distances of the sun and moon almost as accurately as the astronomers of today:—and Pythagoras, who first taught that the sun, and not the earth, is the centre of our planetary system:—and Eratosthenes, who first calculated the circumference of the earth:—and Hipparchus, who calculated the orbits of the earth and moon, and the times of their revolutions, the precession of the equinoxes, and the positions of many of the fixed stars.

Truly marvelous results, these, considering the rude arcs, and sectors, and gnomons, with which these men had to work; then, too, the time-clock and the telescope had not yet been invented.

And in the early days of Astronomy, we find the priests of Babylon and of Egypt, and the philosophers of Greece, all lacking in that knowledge of Geometry which was necessary to exact astronomical calculation.

Plato tells us that about the year 400 B. C. he had gone to Megara to attend lectures on Geometry by a Greek named Euclid, whose fame as a mathematician had spread even beyond Athens. And Plato was so impressed with the importance of Geometry, that when he founded his Academy some twenty years later, there was inscribed above the entrance these words, "Let no one ignorant of Geometry enter here." And Aristotle, having been a student of Plato, before founding his own school, also insisted upon this preparatory requirement. So that the schools of Plato and Aristotle gave a great impetus to the study of Geometry, and Euclid became the "best seller" of the century. And its sale has been increasing ever since. And for more than two thousand years, the universities and colleges in all lands have said to the youth in search of education, "Let no one ignorant of Geometry enter here."

The fame of Euclid had, before his death, spread throughout the world, and his work on Geometry was acclaimed the "most finished product of the human intellect."

Before the end of the third century, another Greek mathematician and astronomer, Archimedes, had given the world a treatise on the properties of the sphere and cylinder, and in the following generation Apollonius published his demonstrations of conic sections. And thus the Greeks, within a century, so perfected the science of Geometry that the world has added little to it since.

Another field of knowledge which invited the investigation of the learned and inquiring mind was that which we now call the science of Medicine: that science which has for its object the amelioration of human misery, the preservation of health, and the prolongation of life.

It included first a knowledge of embalming, of drugs, poisons, and antidotes: of infantile and venereal diseases, of toxicology, of insanity, and of obstetric surgery.

Progress in its development was delayed during many centuries through superstitution, sentimentalism and mysticism. The body was a sacred and holy thing, "a home to house the soul." And the dissection of the human body was a desecration, and thought to invite divine displeasure. So that dissection does not appear to have been safely practiced until about the second century. And then only a macroscopic knowledge could be gained, for mechanical ingenuity had not yet found a way to multiply indefinitely the resolving power of the human eye.

So that when the Greeks collected from all lands the fragmentary knowledge of the human body and its treatment, added this to their own acquired knowledge, and called it THERAPEUTICS, they gave to the world a science almost wholly empiric.

How much of this knowledge they borrowed from other and older countries is not certain. While we know of the existence of Chinese and Hindu manuscripts on surgery and pathology, many centuries before this, we know little concerning them.

The earliest treatise on medicine and surgery with which we are familiar is that of Hippocrates born about 460 B. C. His works, comprising sixty volumes, were written in the Ionic dialect of Greece, and part of them, it is said, have gone through 300 editions.

The great principle of his practice was *trust* in *nature*. He had unbounded faith in the recuperative power of the living organism. "Merely give *nature* a chance," said the Father of Medicine, "and most diseases will cure themselves."

He emphasizes the physiologic unity of the body, and has no patience with the "tyranny of names." (And in the practice of therapy today there seems to be a very pronounced and commendable tendency to follow the teachings of Hippocrates.)

For several centuries following the death of Hippocrates, there seems to have been an increasing tendency to localize disease. This, no doubt, was fostered by the intensive study of Anatomy in the Schools of Alexandria. It was good logic, that if the body was made up of specific parts, and if certain parts became diseased, then by curing all the diseased parts, the whole would be cured. Why not?

This seems to have been the general attitude of the profession, in the middle of the second century, when Galen went to Rome to practice medicine. Galen, who was born in the Grecian village of Pergamos, was the most brilliant and learned of all the medical men of antiquity, and one of the most learned and accomplished men of all time.

Among his voluminous writings written in the finest style of classic Greek, are about 500 volumes on Anatomy, Physiology, Pathology, and the Philosophy of Health. His observations and suggestions on Health are especially interesting. He lays great stress upon gymnastic exercise, hot and cold baths, the use of wine, and three meals a day.

He tells us that when he went to Rome he found the practice of medicine reduced to the science of "finding a label for each patient, and then treating the label."

Galen belonged to no one of the schools of medicine of his day, but was a consistent disciple of Hippocrates, and endeavored to bring the practice back to his teachings.

He also opposed the prevailing mercenary spirit of the profession and their "trade—unionism," for which he was slandered and persecuted by the doctors of Rome and forced to leave the city.

But, may be, the doctors were not so much to blame for this mercenary spirit, for it was fast coming to be the prevailing spirit of the Roman people. For Rome had conquered the world under the Caesars, and her victories over foreign peoples had added numerous provinces to

her domains; and these subjugated provinces had brought her many slaves, and countless riches, and in their train idleness and a love of ease; and licentiousness and profligacy; and those political and social conditions that led inevitably to her disintegration, and her subjugation by the more virile Germanic tribes from the north.

Roman civilization developed the Art of War, and the Science of Civil Government, but added little to the knowledge of the living organism. The day of the physical and physiological chemist, of the electro-physicist and the electro-physiologist had not yet dawned.

Neither Hippocrates nor Galen, with all their learning,—and they were the great physiologists of ancient times—could visualize the future discoveries of the chemist and the electrician, in the fields of cellular investigation. The world was not yet prepared to study the cell, as the structual element of plant and animal life.

And now about the fourth century A. D. that great cataclysm,—the Fall of Rome—put a stop to the intellectual activities of men everywhere, and Science slept for a thousand years.

Recorded history has now brought us through four thousand years. It has shown us great development in almost every field of learning, and especially in those centuries between Socrates and Cicero. It has shown us many great religious teachers, and philosophers, and astronomers, and mathematicians, and men who achieved marvelous results in other fields when we consider their handicaps. But Physical Science—the knowledge of the properties and forces of matter—the laws of gases, and liquids; of mechanics, and chemistry; the phenomena of heat and light; of magnetism, and electricity, all this was an unexplored field, and required more centuries of observation and collation of facts, and inventive genius, than were possessed by the people of antiquity.

The Astronomer lacked the telescope because he did not know the laws and properties of light and lenses, and his calculations were not exact because he lacked the knowledge of the refraction of the earth's atmosphere.

The Anatomist lacked the microscope, and without its aid in magnifying the power of the human Eye, he could not know his Anatomy, and without *microscopic Anatomy* he could not know his Pathology. And because there was little known of *light and lenses,* and of the *Anatomy of the Eye,* there was little upon which to base a *theory of Vision.*

It is said that Claudius Ptolemy, a Greek Astronomer of Alexandria, in his compilation of Astronomical knowledge, called the Almagest, devotes a few pages to a discussion of the *Natural Faculty of Sight,* but this has long ago been lost.

Aristotle, Euclid, and Archimedes are also said to have suggested ideas as to how the Human Eye sees, but the writer has no knowledge of what these theories were, further than that Aristotle talks about

the *"Divine Essence in the Eye" that enables us to see.*

When the temporal power of Rome ended in the fourth century, the priest seized the sceptre, and for a thousand years the Church ruled the State, and religious dogma absorbed the interest of the learned. The Priest was the man of learning. Science was frowned upon by the Church lest it undermine the teachings of the Scriptures. And he, who was bold enough to antagonize the Church, and dispute the Book of Genesis, was summoned before the bar of the Inquisition,—his writings burned, and himself imprisoned. This period of a thousand years, when the Church was supreme, and Science was suppressed, is known as the Dark Ages.

During this period an Arabian scholar named Alhazen investigated the properties of light and lenses, and their adaptation to the Eye, and published a small manuscript on the subject.

And Roger Bacon, a Jesuit Monk of the thirteenth century, is said to have made and worn a pair of spectacles, and to have formulated a theory of vision. But their speculations seem to have been of little value.

And now about the middle of the fifteenth century the world began to awaken from its long sleep.

Whether the Renaissance which began about the middle of the fifteenth century and lasted for some two hundred years, was simply the gradual and natural process of the human mind awakening from a long sleep, or whether it was due largely to the capture of Constantinople by the Turks, and the bringing to light of many Greek manuscripts, which the world had not seen for more than a thousand years, is one of those questions which will forever invite discussion.

But of this we are certain—that the dissemination through western Europe of this Greek literature, comprising practically all known philosophy and science, was a great inspiration to learning, and gave great impetus to the study of that classic language,—the key to all the learning of the past, and the source of most of our scientific terms today.

As in ancient times Mathematics and Astronomy now attracted many of the brighter intellects.

In Astronomy, the names of Kepler and Galileo and Newton are of especial interest, because to them the Science of Optics is directly indebted.

When Tyco Brahe died in 1601, and Kepler succeeded him as Mathematician and Astronomer to the Emperor Rudolph of Austria, his increased income, permitted him as never before, to give his undivided time to his favorite pursuit of Astronomy. For some years he had been trying to prove his speculations as to the shape and size of the planetary orbits and the times of their revolutions. The great perplexing problem that vitiated all his calculations was to know how much the angle of parallax was altered by the refraction of the earth's atmosphere. This he solved by his experiments with water and glass, and in 1606, he gave to Science his two *laws of refraction;* and three years

later his laws of Planetary Motion. And the "world of learning" acclaimed Kepler one of the great benefactors of mankind, and his laws the greatest triumph of human genius for two thousand years.

Turning his attention now to the problems of Optics, he determined the methods of calculation of the principal and conjugate foci of lenses, and also of combinations of lenses, as in the telescope and microscope, and constructed a telescope for his own use, about the same time that Galileo constructed his. He also explained the cause of the aberration of spheric surfaces, and the critical angle of refraction of plane surfaces.

Taking up then the study of the Human Eye, he found that the Cornea and the Crystalline Lens should, by the laws of refraction, focus an external object upon the Retina, forming there an inverted image, and this he confirmed by observation, beyond any reasonable doubt. So that his laws of refraction and of planetary motion and his hypothesis of visual accommodation were accepted at once among all men of science everywhere; and they stand today as unquestioned by the student of Optics, as by the Astronomer.

In his book, which he called "Dioptrics," published in 1611, he discusses refraction of lenses, and of that part of the mechanism of the Eye, which nature had so obviously adapted to the function of accommodation. He shows how the static Eye may be Myopic or Hyper-opic by being too long or too short for the refractive power of what we call the compound system of the eye, comprising the Cornea and the Lens, and how this may be neutralized with glass lenses, so as to make a perfect focus upon the Retina. *In ascribing the Accommodation of the Eye for different distances to the increased convexity of the Crystalline Lens, Kepler gave to the Science of Optics the basic truth upon which the whole superstructure has been builded.*

The hypothesis of Kepler as to Accommodation was confirmed later in the century by that great Dutch physicist and astronomer, Christoph Huygens, who gave us also the undulatory theory of light; and a few years later by that greatest of all scientists, Sir Isaac Newton, who gave us the Law of Gravitation, the most important contribution to Science in all time.

In his work on Optics (1704) Newton accepts the ideas of Kepler, and adds much positive knowledge of the phenomena of light, embracing the Dispersion by prisms, and the Chromatic Aberration of Lenses, which have proven of much value in studying the problems of Vision.

A little later, Thomas Young, a learned physician and physicist of London, who first determined the cause and correction of astigmatism, and who advanced the first theory of Color Vision, proved by his own experiments, that the Cornea was uninfluenced by Accommodation, that the length of the ball was not perceptibly altered, but that the Lens increased its convexity, sufficiently to account for the increased dioptric power of the Eye.

But Kepler had wisely declined to submit a definite cause for the change in form of the Crystalline Lens, further than to suggest that it might be due to the "contraction of the Ciliary Processes." Nor did he attempt to explain how the mind perceives the images formed upon the Retina. Neither Huygens nor Newton nor Young attempted the solution of these problems. This they reserved for the Anatomist of the future, when the perfected microscope, with its greater magnifying power and clearer images, should permit a more minute and exact knowledge of the tissues of the Eye and Orbit.

Now for more than three thousand years many of the problems of Astronomy had been awaiting the day when the magical power of the *glass lens* should bring the hitherto unseen things of the universe within the field of human vision. And when that learned astronomer and mathematician, at the University of Padua, (in 1609), constructed a tube, containing a convex and a concave lens of such powers, and so placed, as to magnify three diameters, "Galileo's tube" was hailed as the greatest invention of the centuries.

(And little do we appreciate in this age of supreme inventive genius, how much our marvelous discoveries and inventions of the past century have been dependent upon the magical power of the glass lens.)

And having made his telescope, and being conversant with the laws of Refraction, (for Galileo and Kepler were friends and correspondents), it was an easy matter to construct a microscope, which he did in the following year. But we must not think of Galileo's telescope and microscope as the perfected instrument we now use.

For the composition of the glass must be made to give a greater transparency to the lens, and they must be made aplanatic and achromatic, so as to give a clearer image; and methods of adjustment must be perfected.

It was more than two centuries before the microscope had reached that degree of perfection which the *researches of Anatomy demanded.*

It was not until the time of Johannes Müller in Germany, and Bowman in England, and Wallace in America, (less than a hundred years ago), that the microscope revealed the meridional and radial and sphincter fibres of the Ciliary Muscle, and confirmed the suggestion of Kepler that the actuating agent of the Lens lay in what he called the Ciliary Processes.

The Ciliary control of the Lens was soon thereafter confirmed by the investigations and experiments of Von Helmholtz, the most eminent name in the field of Optics, and one of the most versatile and learned men of the century.

His work on Physiological Optics, has given him the undisputed title of "Father of Optics," and no student of the Eye should imagine he has "learned it all," until he has mastered the writings of Helmholtz.

And so the question of "how we see," has to a great extent been solved.

The mechanism involved in the act of Accommodation is as well known as the structure of the vertebrarium.

That the rays of light passing into the Eye from the object of regard are refracted by the Cornea and Lens so as to form an inverted image upon the Retina; and that the refractive power of the Eye is altered through the increase and decrease in the convexity of the Crystalline Lens; and that this change in the Lens is actuated by the contraction and dilation of the Ciliary Muscle, are no longer matters of speculation.

This hypothesis of the mechanism of Accommodation has been generally accepted by all writers of Physiological Optics since the time of Helmholtz. To every student of the Eye it has become so obvious as to place it beyond the field of intelligent discussion.

"With this assurance on my part," not as Master of Ophthalmology, but only as a candidate for that exalted honor, let us now proceed to a brief review of a few things we do not know; problems involved in the act of Accommodation, which are still speculative.

The exact nature of the contraction and dilation of the Ciliary Muscle in its several quite distinct sections: the origins and paths of the nerve impulses that innervate its meridional and radial and sphincter fibres: whether it contracts and dilates as a whole, or whether it has antagonistic fibres, for contraction and dilation; these are questions upon which very little has been written.

With few exceptions, the Ciliary Muscle has been considered, by writers on Anatomy, as a physiologic entity. This is not analogous to other sphincter muscles of the body. Nor is it in harmony with the physiology of muscle, in general. This view of its action will not bear rigid analysis.

The influence which the *shape of the head*, and the *consequent variation in the angles of the orbital axes*, exert upon the extra-ocular muscles, is a problem that has received very little consideration.

Then the exact changes which take place in the anterior and posterior surfaces of the Lens during Accommodation; whether they follow the laws of liquids when assuming a more spherical form, or whether the anterior surface increases its convexity near the axis, while it decreases near the periphery: the change in curvature of the sectional layers of the Lens: how its change in shape affects its spherical and chromatic aberration: these have long been questions of active discussion.

Another problem which invites our consideration is the possible change which may take place in the Cornea. It has been proven by satisfying experiments that the Cornea is not altered perceptibly during a brief act of Accommodation. But this does not prove that the almost continuous tension upon the Cornea, of the very Hyperopic Eye, by the Ciliary Muscle, and also by the extra-Ocular muscles, which must

be greatest in the horizontal plane, does not in time alter its form, and give us that abnormal astigmatism which so often appears in the Hyperope of advanced years.

The problem of the development of Myopia seems to find no solution sufficiently plausible to place it in the field of general acceptance.

Then the mechanism of Color perception, and how it functions, for which so many theories have been advanced, is still to be satisfactorily explained.

Then we have the problems of binocular Accommodation. Most of us have two Eyes, which insist upon working together in perfect harmony, and in receiving an equally clear image upon the Retina, if this can be done without too much strain upon the musculature of the Eyes. It is obvious that the balls are rotated through the agency of the extra-ocular muscles; but the harmonious adaptation of the two Eyes to every point within the visual field, is still a subject that invites discussion.

Probably the most interesting problem of the Physiology of Vision is the transformation of the light-image upon the Retina into the nerve current, which passes back to the reflex centres and visual areas of the brain. Physiological Chemistry has been trying to solve this problem ever since the time of Paracelsus, who converted the medical profession from the prevailing belief in "humoral pathology," to the idea of "chemic influence" in the tissues, as the basic cause of all disease. But a study of chemic change has not solved the problem.

The treatise on "The Principles of Physiology" by Sir William Bayliss, the most learned and profound work on this subject in the English language is a disappointment to the student of Visual Optics.

It may be that the discovery of the mineral selenium, by the great Swedish chemist Berzelius; and the experiments of Sir William Sieman with his "Selenium Eye"; and the discoveries of Arthur E. Baines concerning the electric reactions of plant and animal tissues; and the researches of that great scholar of India, Jagadis Chunder Bose, as set forth in his work on Electro-Physiology, may yet solve the problem of visual perception.

And so a brief review of the past shows us that, for the benefit of Astronomy the Laws of Refraction were found; and for the benefit of Anatomy, the microscope was invented; and out of the knowledge of Refraction and microscopic Anatomy, Optics was born.

It was a long time from the superstitious belief of the Chaldean Shepherds that a "Divine Fire" in their Eyes enabled them to see, until Kepler's hypothesis of the mechanism of vision laid the foundation stone of Optics.

The superstructure will be completed when we have solved all the problems of Visual Perception.

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THE CORRECTION OF SQUINT ON THE DOMINANT SIDE*

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The modern correction of squint involves more than has been ordinarily thought of in connection with squint. It is not ordinarily deemed necessary to consider the fact that every normal individual seems to be endowed with the tendency to depend upon one side of his body more than the other. The dependence apparently is wholly sub-conscious and therefore without intent. Upon this premise it follows that one hemisphere of the central nervous system attains dominant control in the normal bi-lateral man.

Therefore in the correction of an eye squint we have first to take into consideration the natural dominance of the brain of the patient under examination. It has long ago been determined that one's dominant handedness is but a natural envolvement of dominant side of brain. If the right side of the brain happens to be the controlling factor in directing one's activities of the hands, such an individual is certain to be left-handed. On the other hand if the left side of the brain is the controlling factor in use of the hands, such one is most certain to be right-handed. It is not disputed that variations are occasionally found. Neither is it disputed that sometimes we find a case in which, apparently, either side of the brain is known to be the motivating factor in hand movements. We then have an ambidexterous personage, one who finds it equally convenient to use either the right or left hand in ordinary usage. Writing is the usual tell-tale activity in which determination of handedness is most easily brought about.

Handedness and eye-edness are immutably associated in the normal bi-lateral development of man. It is of interest to note that handedness and footedness are not as immutably associated. The probable reason being that of facilitating equilibration in major bodily movements.

If one would satisfy himself of the close association between

*An abridgement of the material presented before the American Academy of Optometry at Omaha, December 14, 1930.

handedness and eye-edness, he has but to invoke the classical test for eye-edness. With both eyes open, direct the index finger of the right hand at a point target. Now close the left eye and determine whether or not the finger is still in line with the point target. If it is, the individual is right-eyed. To check, again open both eyes and direct the index finger of the left hand at the point target. Now close the right eye, and if the finger is not in line with the point target, right handedness and right eye-edness are proven to exist in that particular case.

No matter whatever else is investigated in the prognosis of squint correction, it is the writer's opinion that primary importance lies in the determination of the dominant eye and handedness. Having made the above test for dominancy of eye, we must now relate the habitual handedness found. Note the word *habitual*. During the past generation or two there has been an apparent stigma placed upon left-handedness. In an effort to efface this superstitous dogma, left-handed children were compelled to shift to right-handedness. In a child, this is not as difficult of accomplishment as one would at first suppose. Constant drilling and approbation soon builds a habit of right-handedness that is as foreign to the natural progress of the child as anything could be. But aside from the awkwardness of the child's use of the hands, a more serious and subtle development is started within the child's mental processes. This does not involve a pathologic nor physiologic change. There develops a hesitancy amounting to a "psychic block," a mental impediment that materially slows up mental processes. Stuttering has been a common aftermath of this effort on the part of parents in attempting to improve upon nature.

The "psychic block" is a psychic disturbance set up by disturbing the normal association pathways between the visual centripetal sensory nerve impulses and the motor centrifugal nervous impulses. Instead of using the receptor *and motor* areas on the right brain (in left-handed folks) the right brain *receptors* are incited by the left dominant eye, and instead of the reflex through the right motor areas to the left hand for action, the individual has been forced to inhibit the natural reflex in the dominant side of the brain, and to *will* a new association pathway from the right visual area to the left motor area in order that the right hand may be innervated. The so-called "psychic block" arises in the inhibition of the normal reflex within the right brain, and the *willed* act of pushing through ruthlessly upon unnatural pathways, viz., from the right sensory to the left motor, nervous impulses that normally are unnecessary. The normal reflex arcs within the same side of the brain are smoothly carried on. To interrupt such smooth and natural activity requires deliberation and *willed* inhibition and *willed* innervation. This is time consuming and develops considerable confusion in mental habits.

The changing over of a natural left-handed child to right-handedness is an injustice to the child and an insult to nature.

The possibility of such a change-over in a patient's infancy is most essential to be known. It is sometimes difficult of ascertainment.

In cases where there is no squint present and where no glasses are tolerated, if reference is made to the test for dominancy, we very often find that the dominant eye has been made inferior to the non-dominant in visual acuity. The minute the dominant eye is restored to dominancy in acuity, the intolerable situation has been obliterated. In conjunction with this, it may not be amiss to note that if either of the two eyes is *inadvertently* blurred below its mate it will be best to see to it that the non-dominant eye be the one of sub-acuity. As certainly as we blur the dominant eye in the average refractive case, just so certainly will the correction be intolerable to the patient. A blur of the dominant eye artificially transfers the dominancy of the visual centers to the opposite side of the brain. This constitutes an artificial "bloc" in which the patient reports that he doesn't know what really is wrong with his glasses, but that they simply drive him frantic. And well it might. The dominant eye has been intruded upon and the habitual dominant brain hemisphere has been dethroned in favor of its opposite mate.

If ever there was a house divided against itself, here it is! Intolerable is the most appropriate term applicable to the situation thus created. It is very true that the only disturbance has been psychic, but I submit, that, after all the psychic is the most profound disturbance to be found, and the most easily remedied once it is definitely isolated. But herein lies plenty of difficulty. The recognition of psychic disturbance relative to the correction of squint is a matter truly within the scope of optometry and positively necessary in the correction of certain types of squint.

Pre-eminently in these certain types, that of squint on the dominant side stands clearly in the foreground.

Therefore when a case of squint presents itself for correction, the first procedure is that of ascertaining the dominant side. If the individual is right-handed and presents a right eye squint, we must first determine beyond question whether the right-handedness is natural or artificial. If natural, we have a squint on the dominant side; if artificially right-handed, i. e., naturally left-handed, but changed over to right-handedness because of pressure being brought to bear, we then have a squint on the side opposite, or non-dominant eye squint. It is perfectly obvious that the two possible conditions cited, require totally different technique in correction of the squint present. This is not new material. Peckham has covered the field of dominancy as applied to handedness and eye-edness. I merely emphasize the great importance of determining definitely the status of dominancy in the hands and eyes of every individual. It is positively necessary in the correction of squint. For example, a right-handed individual with a left eye squint presents a problem totally different and more easily corrected than a right-handed person with a right eye squint. It is interesting to note

that left-handed folks with left eye squints are very rare personages. Left-handed folks with right eye squints are relatively common. Their numbers, however, are few; there being fewer left-handed folks than right-handed. Right-handed folks with left eye squints are common. Right-handed folks with right eye squints are not as common, but when they present themselves for correction of the right eye squint, heretofore the correction has been very slow and more often than not, impossible of correction. In correcting any squints, the causative factor must be found if possible and remedied when found, if it is possible so to do.

In all squints on the dominant side, we may safely rule out latent hyperopia. We may as safely consider squints on the opposite side of dominance, due to latent hyperopia. There will be recalled to your mind several instances where the foregoing seems not to be applicable. A more closely scrutinized review of such cases will be found to measure up very closely to the above generalizations.

Having ruled out latent hyperopia in dominant side squints, we must determine, if possible, the probable cause. Peckham relates fear as being the primary cause, with enteric disturbances being secondary in frequency in which they are found. Case history is of utmost importance and a careful study should be made of it. Squints in small children where the squint occurs on the dominant side, must give a definite history which should be analyzed for definite information as to the probable cause of the squint. History of whooping cough, in which squint occurred, I find is most often given of small children's cases. This of course is caused by fear of choking rather than the choking itself. A psychic disturbance is set up by the deathly fear engendered by a temporary shutting off of the trachea through involuntary muscular innervation. The psychic disturbance leaves an impress upon the child's mental life. This impress is deeply rooted. Seldom is the child conscious of the existence of any fear. But let the same circumstance reoccur, and the fear rises immediately to the surface and the involuntary reflex is again experienced.

The involuntary overtone of nervous innervation seems prone to travel fairly well known channels. We get a definite eye involvement that is always associated with fear. When, however, the sudden fear grips a child who is unable to cope with the matter, the eye involvement is more pronounced. Adults register fear in ocular manifestations, but seem to have the faculty of mitigating its extant. Possibly the adult memory serves to stem the tide, subconsciously. In small children, past experience does not exist and they suffer the full brunt of the onslaught of the psychic disturbance induced by fear.

In cases where a definite history of fear is presented, it is the writer's opinion that the cure of squint rests in the obliteration of the fear. In rational adults, psycho-analysis employed through a competent practitioner has served to very good advantage. The procedure being to dig up the latent or obscure cause of the fear, and after bringing the cause to light, the rational adult recognizes the absurdity of

the fear, and once recognition is had, the fear is dismissed from the mind, or is banished through a lively sense of humor.

In children, psycho-analysis is difficult of accomplishment. They seem not to "know" their own minds.

Children present a very splendid field for use of suggestion in the correction of squint. Adults too, are subject to corrective stimulation through the power of suggestion. It seems, indeed, to the writer that much of our success through instrumentation has been brought about by the very subtle, though powerful, suggestion that is carried home to the sub-consciousness of the patient, by our very efforts to accomplish something good for them.

The writer accidentally stumbled upon the possible extent to which suggestion may be used in the correction of squint. We had a patient of marked credulity. In making a duction test one day, we found that the individual could duct in or out to an extremely marked degree and found upon subsequent examination the duction was only a fractional part of the first test. We told the individual that we were surprised at her inability to do as well this day as on the day previous. By insistence on our part, and by tactful urging and suggestion, we were able to again obtain the very wide ductions of the day previous. This one case started us thinking along the line of power of suggestion, and this has been some three years ago. We have tried innumerable different experiments in numbers of cases, wherein by careful, unobtrusive suggestion, there have been astonishing results in so far as the deviation from the normal that is to be expected.

We do not mean to infer that this has been done in all cases, nor even in the majority of cases. We do go on record as having experienced remarkable response to suggestion in certain typical cases. These cases are typical in that they are susceptible to suggestion, more so than the average. They are of the dreamy type in which most powerful reactions are given to suggestions that reach the lower level of their consciousness. The reaction seems to be automatic, positive and seemingly effortless.

The writer commends the subject of suggestion to the members of this body for further research and experiment. He feels that here is a powerful corrective agent that is not being employed to our ultimate benefit.

To return to the orthodox methods of squint correction; we feel that added assistance can be had by employing, deliberately and scientifically, the power of suggestion to the elimination of psychic blocs and the promotion of normal synergism and normal reflex arcs within the proper cerebral hemisphere.

Working with the accepted instruments of squint correction, the writer has found that convergent squint on the dominant side has not yielded to treatment as well with base-in prisms used arbitrarily, as with a judicious amount of base-out prism in conjunction with the

usual orthoptic work. The base-out prism value should always be kept within the angle of deviation. The purpose being to cause the image to fall more nearly within the field of maximum retinal stimulative areas. Prism base-in used arbitrarily in this type of squint has never proven of any assistance to the writer. There seems to be no incentive for co-operation on the part of the patient. The futility of effort soon defeats our purpose. On the other hand, with base-out prism, in this type of squint, of an amount less than the deviation angle, we find the patient realizes that he is accomplishing actual results by his efforts to bring the eye in line with the object. We find very often that over-stimulation to the external makes necessary frequent reduction of the base-out prism, when the patient is making an effort to orient the squinting eye to more nearly parallelism with its mate.

Orthoptic exercises, with the patient holding the non-squinting eye, and prism base-out over the squinting eye, is resorted to for motility of the squinting eye. The patient is seated at an angle approaching ninety degrees, so that the orthoptor or squint corrector, is at the patient's side on which the squint is present. Kratometer exercises are resorted to after sufficient motility is established. It is with the kratometer that suggestion is brought to use with very good results.

With the patient relaxed physically and in a passive mental state, we say to him that he is expected to follow directions closely. An effort is then made to obtain definite diplopia under control. We are then prompted to call upon the patient to see the two targets in various positions in the horizontal plane. By simple suggestion, ofttimes a patient is able to fuse two targets, notwithstanding the fact that no change is made in the prism values before the patient's eyes.

You have undoubtedly experienced various degrees of success with various methods of corrective work in ordinary squint. I hold that theoretically all effective means of squint correction should react similarly in all cases. It is manifest that this does not work out in practice, the probable reason being that the patient is affected differently by the mere fact that certain techniques suggest certain psychic reactions. The technique that is most effective in any given case, is the one that proves most effective in implanting the correct mental impetus for corrective action on the part of the mind of the patient.

Briefly, then, the correction of squint on the dominant side consists of recognition of the causative factor, elimination of the causative factor, establishment of motility and fusion through proper education of the fusional faculty.

Of these the most difficult of accomplishment is that of recognition of the causative factor. Too much time cannot be spent in determining the probable cause of the squint, the age at which it appears and any co-related facts of the squint occurrence.

The elimination of the causative factor is not as difficult. In adults psycho-analysis should be resorted to. The probable cause is thereby uncovered, and once recognized, is taken care of by the patient himself. In children, the use of suggestion under proper control has great possibilities. At present, too few men are able to properly control the patient in order to impart therapeutic suggestion to the patient's subconsciousness. However, under the proper conditions, suggestion thus imparted, is capable of amazing curative powers. Hence, my request to this body, that the matter of suggestion as a curative agent be further scrutinized, and further studied.

The third phase of correction, that of establishment of proper motility in the squinting eye, is now well understood and practiced widely. It is my opinion that intelligent use of these motility techniques are closely associated with suggestion. Who can say that an inanimate thing as a machine or instrument, cannot be the means of imparting, insinuatively, a desired suggestion from the operator? Oftimes such suggestion is more effective than words.

When this is found to be the case, the reason lies in the fact that the instrument or machine, by *action*, speaks plainer than the operator's words. To explain a complicated and highly involved technique, does little to impress upon a patient's mind what is expected of him, and what we know he is capable of doing in assisting us in his treatment. A machine can take much for granted on the part of the patient, and demands, without argument or question, that certain response from the patient that follows when his attention is captured and held by such a machine or instrument. No more positive suggestion is ordinarily found than that imparted in this manner. My plea is that the scientific study of suggestion and its power to cure be further enhanced by a concerted action on the part of this scientific body of men.

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FUSIONAL TREATMENT WITH THIRD DIMENSION TRAINING SERIES*

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Before going into any length on the subject of stereopsis, I would like to call the readers' attention to one thing, that is that during the years I had devoted to study, investigation and writing, my desire was primarily to present data of interest to the profession. When the Keystone Instrument was first introduced to Optometry (Keystone View Co., Meadville, Pa.) it had a magnetic force to me as an instrument with many possibilities. Therefore it has been for some time, somewhat of a toy to me, something to experiment or play with. Through constant increased interest and final apparent conviction I am of the opinion that it was worth my work in experimenting with it, hence it shall be worth the effort of my recommending it to the profession. It has been always my desire to recommend exclusively that which I think is of benefit to the practitioners.

The instrument is best placed on a table, the exact height being adjustable through the small stand upon which the two tubular arrangements are mounted. The patient is placed in a comfortable position so that his eyes shall be on level with the eye tubes. Each tube has a five and one-half diopter prism, base out, making the optical system conform with the needs of a stereoscope. On the extension the pictures are placed and can be brought closer or further away, depending upon the clearness of pictures. The septum is removable.

What does this instrument do, is the question of paramount significance. It assists us to train the mind for perception of depth. The stereoscopic photographs with this instrument attracted my attention and left me thinking and working. Will training of depth (third dimension) help us straighten a strabismic pair of eyes or at least can it give partial relief to the appearance of the patient? In my recently published book I advocate, as many others do, the developing of the amblyopic eye, and stereopsis will develop mostly automatically. However, it is still a superior method to train depth perception, for it will at once call on all visual perceptive efforts of both eyes. The most in-

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teresting phase can be traced to the stereoscopic photographs. Space does not permit to mention all pictures, but this discussion would not be complete without describing some. The two sets showing the baby's bath permits quite a variation of convergence. Among the large pictures, best results were expected to be obtained from: Man with big feet; passageway along Norway waters with mountains in the rear; pictures with the sheep; etc. In all these photographs the patient under training is permitted to converge to various points due to many minor details present, and the far distant objects which do appear very far with this form of stereoscope. This permits the patient not only to attempt to fuse, and to see depth, but also to vary the position of the eyes without loss of interest. The simplicity of some pictures and the intricacy of others permits its usage in early and advanced stages of development.

The question may arise as to why third dimension, i. e., depth perception, is it of assistance in fusion training? The answer is partly given in the preceding paragraph, and further we could say that once we can get the brain to be educated to the point that there is such a thing as depth, it will try on its own accord to acquire it. It is similar to a person who never rode in an automobile but had to walk instead, and then learns its comforts through experience, then he would look for the possibilities of this more comfortable vehicle.

Many a time we purchase an instrument and at once we claim that we know how to straighten cross eyes. It is not the instrument that does the training; it is only a means through which we apply our mental processes to a given stimulation. In other words, the human element of the patient comes first, the mental attitude of the refractionist comes second, but neither of these would be complete without the third element, the conrecting object, we call instrument. Now then, why say that stereopsis should be forced when we have a case of strabismus. It is my contention that set rules cannot be laid down in any case. What we should do is to analyze the case as to its cause. If we have strabismus, it may have resulted from many things and what we should do is to eliminate the cause rather than blindly proceed in like manner in all cases. If we look for the cause and then eliminate it, regardless of what it may be, we will be much more successful. To put on full plus corrections prove satisfactory where we can trace the cause of the strabismus to its under correction. However, in the majority of cases, strabismus resulted from under developed fusion faculty hence stereopsis is needed to be brought up to the par. We can accomplish this by the variety of pictures supplied with the Keystone Fusion Training Series, and the fact that the patient does not have to hold it in his hand, but can be at rest, since the instrument can be placed on a table.

In most cases of strabismus, especially in those if far progressed, we find that one eye is amblyopic. We can do either one of two things in our attempt to train fusion, or stereoscopic vision in these cases. (1) One is to place the small light over the picture which is in front of

the amblyopic eye, thus bring the retinal stimulus of that eye to closer level to the stimulus of the better eye. (2) The other procedure is to shade the picture in front of the better eye, thus equaling approximately the light stimulus. The former is more recommended by the writer. We know from clinical experience as well as from many authorities in research, that coordination between the eye and the hand is definite. In view of this, we can have the patient observe a simple picture or a drawing in front of one eye, while with a pencil we may trace (not draw) on a white sheet of paper in front of the other eye. Inasmuch as colored objects are stronger stimuli of greater help in developing amblyopic eyes, as well as stereoscopic vision, we may use for blank paper various colors, dull ones as well as bright ones, using also colored crayons.

While experimenting with this Keystone Eye Trainer, whether it is recommendable or not to the profession, the writer went a step further and hoped to be able to devise means, without changing the size or construction of the instrument, whereby it could also be used for stereocampimetry of the central fields. While the theory is correct, the smallness of the instrument does not permit any reasonable field. The tube of the instrument does not permit a wide angle, and is estimated approximately to give us an angular field of 10 degrees. In cases of central scotoma whenever the macular area is directly involved, including progressed cases nephritis and diabetes, the macular find can be recorded. Of course in these cases fusion may be difficult, in which event, this central field would be measured monocularly.

In conclusion the writer wishes to express once more the thought that this has been presented to the readers with the view in mind of assisting them in their work of fusional training. To train depth perception means the inducement of all visual perceptive efforts of both eyes, as stereopsis is not possible without using both eyes.

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NON-OPERATIVE TREATMENT OF GLAUCOMA*

J. O. Baxter, Opt. D.
New Bern, N. C.

Mrs. F., a seamstress, age 40, called with a complaint of transient blurring of vision and discomfort in the use of her eyes. Vision O. U. was 20/20. The pupils were wide and reacted both directly and consensually in a sluggish manner. The cornea and lens were normal. The media was clear.

Ophthalmoscope: The right fundus was normal. The left revealed very slight temporal cupping of the disk.

Stereo Campimetry: The right eye revealed a beginning Seidel projection continuous with the upper quadrant of the blind spot of 10 degrees. The left eye revealed a sickle shaped scotoma extending from the blind spot over and above fixation, clearing fixation 3 degrees. Palpitation could determine no increase of tension.

The physical examination by the family physician found the systolic blood pressure 180 with albumin in the urine. She was under considerable mental strain on account of the loss of her husband.

The kidneys were successfully treated by her physician, who at the request of the writer, also prescribed a miotic.

The eyes were treated for two weeks, daily, with 20 minutes exposure to infra red, with complete cessation of her visual disturbance and discomfort, with no recurrence for three years.

A recent examination revealed the same field changes that were originally found. Advice was given at the time to report regularly for observation of any field changes which might occur, signifying the necessity of consulting an eye surgeon for further treatment, surgical or otherwise.

DR. J. O. BAXTER,
NEW BERN, N. C.

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PSYCHOLOGICAL AND PHYSIOLOGICAL FACTORS IN OCULAR FATIGUE

The act of seeing is complex and depends upon more than one simple factor. Until recently, when the act of seeing was considered, only three elements were taken into consideration, namely (1) the refractive (optical) system, (2) the physical size of the object, (3) its distance from the eye.

Recent studies[3] show that a greater number of factors are involved in the act of seeing, namely (1) size, (2) contrast, (3) brightness, (4) time, (5) psychological process, (6) physiological changes. While considerable advances in optometry have been made in recent years these were mostly along the lines of optics, the physiological and psychological aspect was mostly overlooked. It is with great satisfaction that we call the readers' attention to an article by Dr. H. S. Horton, entitled "Physiology of Muscle Action and Fatigue Applied to Myologic Techniques," which appears in this issue. Dr. Horton is trying to approach some of the ocular anamolies, particularly fatigue from a physiological standpoint. It is to be hoped that more work will be carried out along this line.

In investigating the problem of ocular fatigue, we must not lose sight of the fact that there is a great difference between fatigue produced in a nerve muscle preparation in the laboratory and fatigue which occurs in any muscle in a living body. While it is easy to measure and study graphically the fatigue produced in the laboratory, this is rather difficult to accomplish clinically, especially so in the case of ocular fatigue, because of the complex number of factors entering in.

In studying this subject on the human body there are several points of importance to be taken into consideration. (1) We do not get fatigue if we have a long interval of time between contractions. (2) Fatigue of one set of muscles will also effect the neighboring muscles. This is due to the fact that the waste products are carried by the blood stream to the other muscles. (3) Muscular fatigue will be caused by mental fatigue. (4) There is a fatigue condition of FEELING TIRED—here consciousness is effected. There is not much known about this type of fatigue at the present time. It has been investigated considerably by many industrial commissions but no correlation with bodily changes could be made. (5) Mental attitudes and emotional states are powerful factors in the production or removal of fatigue.

All of the investigators who studied ocular fatigue found it a very difficult task to produce or measure it. Some have used the visual acuity method, others again used the balance of the extrinsic ocular muscles, while this latter method is the more reliable of the two yet it is not satisfactory and we are still in need of devising a method which will enable us to get more accurate results.

The difficulty encountered in measuring ocular fatigue is mostly due to the fact that the human body is a complex machine and when its store of supplies is diminished as a result of work, it does not run at top speed, like an automobile engine, but as a moderate depletion of supplies takes place, the human organism begins to anticipate further drains and to protect itself reduces gradually the activity. This protection is of an unconscious nature and merely manifests itself in a tendency to be reluctant towards effort.

From the foregoing, one can see that in our study of ocular fatigue and its removal[1] we must approach the subject not only from a refractive (optical) standpoint but from a psychological and physiological standpoint as well.

From the study of physiology we know according to Bainbridge[2] that during activity a co-ordination of changes takes place within the body. The outflow of impulses from the motor cerebral cortex to the muscles is accompanied by a simultaneous outflow to the respiratory, vaso-motor and cardio-inhibitory centers in the medulla. The blood flow during exercise is accelerated thus bringing to the muscles a supply of fresh arterial blood rich in oxygen. Oxygen in turn helps the muscle to recover from fatigue.

We also know from the study of psychology that emotional excitement extends the range of men's physical power, because it quickens the activity of the entire central nervous system and enables a larger number of impulses to flow not only to the skeletal muscles, but to the circulatory system and to other organs as well. Mental states are also important factors in the study of fatigue. Recent experiments in factories have shown that better arrangements of machines, better lighting, more congenial surroundings, such as painting the walls and the ceilings, pleasing decorations, have a great influence upon the workers. These adjustments in environment have a great influence upon the mental attitude and emotional adjustments of the human beings.

Luckiesh and Moss[3] in discussing this subject claim that "such changes in environment will directly decrease eye fatigue, muscular strain and energy losses." They maintain that "the seeing specialist must open his mind to physiology as well as psychology."

The optometrist, too, we contend, should take a greater interest in the study of physiology and psyhcology. This may help us materially in solving some of the difficult problems where refraction alone failed.

J. I. K.

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ANNOTATIONS AND SOCIETY PROCEEDINGS

The American Journal of Optometry is the Official Organ of the American Academy of Optometry, as well as the Organ of the Arkansas, Delaware, Indiana, Iowa, Maine, Maryland, Michigan, Minnesota, Nebraska, North Dakota, Oklahoma, Pennsylvania, South Dakota, Vermont and West Virginia Optometric Associations.

The following gentlemen have consented to supply items of interest from their respective sections, acting in the capacity of

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ANOTHER A. A. A. O. MESSAGE

Since the American Association for the Advancement of Optometry has come forward with an open and fearless declaration for expansion in optometric service, the more timid ones in our ranks have been encouraged to signs of awakening. While to a certain group, optometric expansion, however logical and sane, is still anathema, others are beginning to lose their fear of ridicule and displeasure, and are giving utterance to repressed hopes and convictions. And so we find optometrists now more willing to speak upon the relative advantages of upstairs against downstairs offices, upon professional conduct as compared with commercial practices, and even upon optometric expansion itself,—the bugaboo of the commercially-minded practitioner.

Dr. Heather of Chicago, is among the first of optometrists with the courage and wisdom to speak plainly upon these allied subjects. While he stresses at this time ethical advancement rather than clinical expansion, his message is a preliminary step to the ultimate aims of the A. A. A. O. Heather's fearless presentation of his subject points unquestionably to the trend of the times.

Those who would ignore normal growth or thwart inevitable progress, let them try to do so. The American Association for the

Advancement of Optometry has faith in the strength and wisdom of those with open minds and earnest hearts; in the future practitioner who will not be hide-bound by tradition, nor swayed by fear and selfishness. Already, numbered among the loyal supporters of the A. A. A. O. are some of the best men in our ranks. They are not all the best intrenched financially, nor perhaps, have they all yet made a mark in optometric circles. They are men, however, with clear purpose and vision; men who do not fear a loss in prestige because of crossing the will or purpose of a few so-called leaders; men who think more of the truth than of policy or expediency, of their profession and human rights than of dollars and human favor. They are men whose work and purpose will be fairly judged by future generations.

Apart from the fact that human instinct revolts against the senseless limitation of our work, common sense and reason support our claim to a bit more than the mere fitting of glasses. Realizing that already in some states an optometrist must have at least four years of University work with a degree in the Sciences or Arts before he can engage in the practice of fitting glasses, is it too early now to recognize the unfairness or inconsistency of the situation, and seek remedial measures either in a reduction of the scholastic requirement, or the addition of such ocular work as proper University training should qualify the practitioner to embrace? The A. A. A. O. does not countenance a reduction in educational preparation. It maintains, however, that a portion of the curiculli should be devoted to teaching practical eye work, of a quality and measure, consistent with the optometrist's present work and with demands made on him in his daily practice.

As optometrists drop the swaddling clothes of spectacle vendors; as their horizon widens by virtue of daily contacts in an atmosphere of growing professionalism, they will begin to sense the reasonableness of the aims which the A. A. A. O. fosters. All will then better realize the sterling opportunity which our program holds in store for them.

Samuel H. Robinson, Chairman,

Prescott, Arizona.

* * * * * *

BOSTON SOCIETY OF OPTOMETRISTS

At the meeting of the Boston Society of Optometrists on Wednesday, March 16, 1932, Henry R. Bloom, M.D., instructor of Ophthalmology at Boston University School of Medicine, lectured on Recognition of Early Cataract.

Following this lecture three films were shown through the courtesy of the Bauch & Lomb Optical Co.

Film 1. Cataract Extraction.

Film 2. Todd-Parker Tucking Operation.

Film 3. The Gold Ball Implantation.

While these films were being shown, Dr. Bloom commented on the process of the operations. These operations were performed by Frank Claveloux Parker, M.D., of the Will's Eye Hospital of Philadelphia.

A general discussion led by Dr. Bloom followed.

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PENNSYLVANIA OPTOMETRIC ASSOCIATION

Dr. M. L. Blum, Secretary of the Pennsylvania Optometric Association announces that the Bucks and Montgomery County Optometrists of Pennsylvania have just held their initial organization meeting for the purpose of establishing a new society. The first meeting has been called by Dr. John R. Wittekind, Morrisville, Pa., for March 31st, 7:00 P. M. at the Doylestown Inn, Doylestown, Pa.

The speakers at this initial meeting consisted of Dr. Albert Fitch, Dean of the Pennsylvania State College of Optometry, Philadelphia, Dr. Edwin F. Tait, Registrar of the Pennsylvania State College of Optometry, Philadelphia, Dr. J. C. Strauss, Allentown, Pa., President of the Pennsylvania Optometric Association, and the writer.

This is the first newly organized local society for this year. The state organization officers hope that another local society will be established in a short time.

* * * * * *

ANDREAE AT CLEVELAND

Dr. J. Fred Andreae, President of the American Optometric Association visited Cleveland, Ohio, during February to assist the local committee in making arrangements for the coming meeting of the American Optometric Association in that city in June. The plans are almost complete and the educational program will be announced in a short time.

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SOUTH DAKOTA CONVENTION

The South Dakota State Association Convention was held on April 10th, 11th and 12th at the Cataract Hotel in Sioux Falls, South Dakota. Dr. Louis Jaques delivered a series of very interesting lectures on "The Blur Point Technic." Much interest was displayed by the members of the new technic as outlined by Dr. Jaques.

Registration took place in the forenoon of the 11th. A golf tournament was played in the afternoon of the same day and the business meeting was held in the evening of the first convention day. The entire day of the 11th was given over to Dr. Jaques. In the forenoon of the 12th a joint meeting of the northern and southern districts of the Skeffington Study Group was held. This was followed by the business session and the election of officers for the ensuing year.

PENNSYLVANIA ANNUAL MEETING

The thirty-sixth annual Convention of the Pennsylvania Optometric Association of Optometrists will be held at the Abraham Lincoln Hotel, Reading, on the 2nd, 3rd, 4th and 5th of October. Dr. S. A. Brown is the General Chairman and Dr. H. M. Clunk is Chairman of Educational Activities.

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NEBRASKA OPTOMETRIC ASSOCIATION

Dr. C. L. Moore, President of the Nebraska Association of Optometrists announces that the attendance at the five educational clinics sponsored by the association is thirty per cent greater in 1932 than in 1931. Credit for this increase according to Dr. Moore should go to Dr. E. B. Alexander who planned the activities of the societies educational program.

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MINNESOTA OPTOMETRIC ASSOCIATION

Dr. Lionel Topaz of Chicago, Editor of the *Optometric Weekly*, Dr. Carl Shepard, Dr. L. Copeland, Dr. L. L. DeMars and Dr. Louis Jacques were the chief speakers at the annual convention of the Minnesota Society held in St. Paul. The 1931 officers were all re-elected and the meeting closed with a smoker. All sessions of this two day meeting were very well attended.

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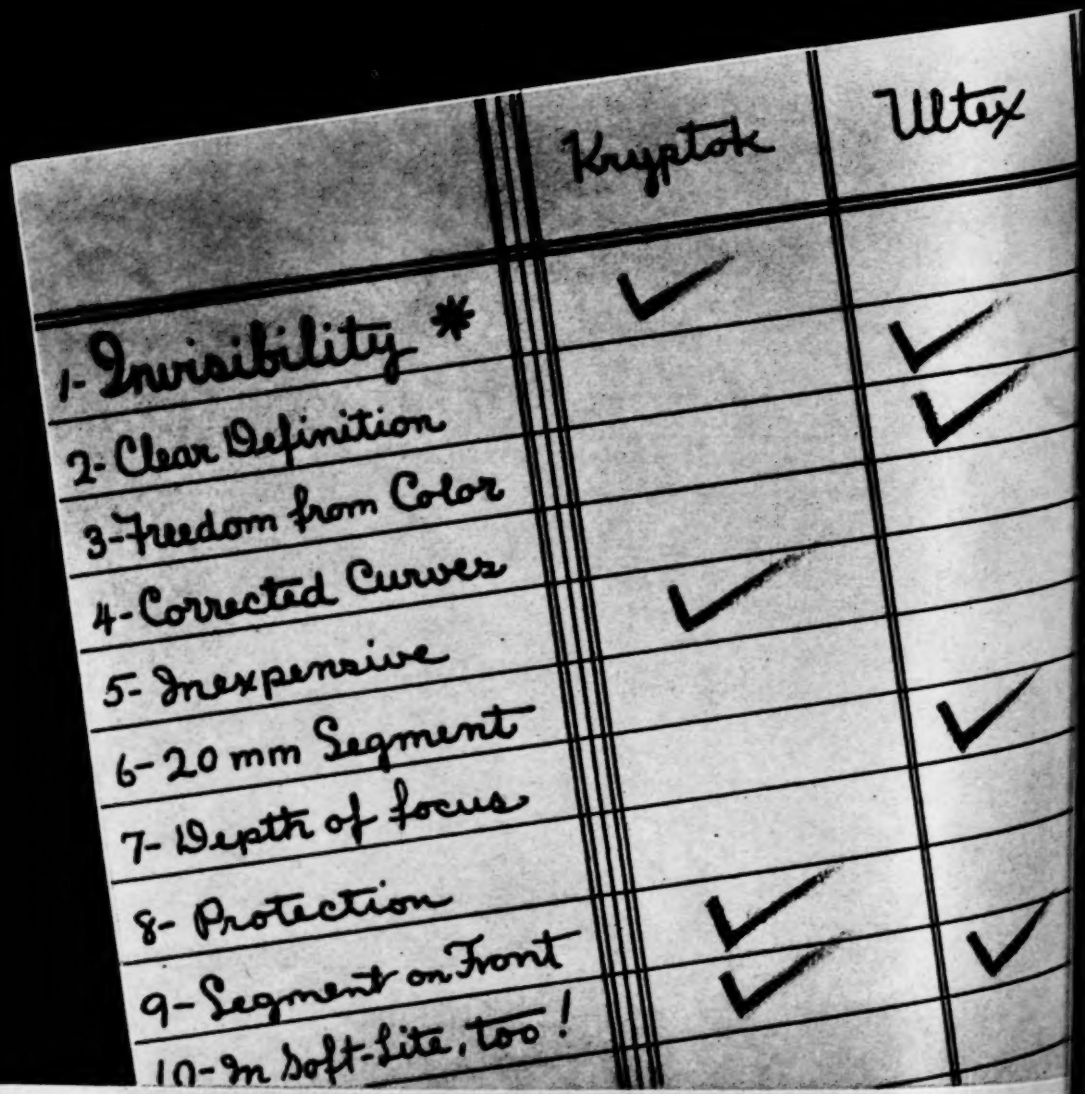
BACK COPIES WANTED

Mr. Ted Schlaegel, Manager of the American Optical Company Branch of Indianapolis, Indiana, is anxious to secure the November, 1931 issue of The American Journal of Optometry. Anyone who can spare a copy of this issue is requested to communicate directly with Mr. Schlaegel at the Century Building, Indianapolis, Indiana.

Check *your* bifocals



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